Tire recycling

Background Paper

BP-431E

TIRE RECYCLING

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26 November 1996

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Catalogue No. YM32-2/431E
ISBN 0-660-17056-6

CE DOCUMENT EST AUSSI
PUBLIÉ EN FRANÇAIS

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TIRE RECYCLING

INTRODUCTION

While used tires are composed of relatively inert material and pose no direct harm to the environment, whole tires are banned from most landfills in highly populated areas. The inherent physical properties of tires, coupled with soil, garbage, gas movement and freezing and thawing, result in the phenomenon of tire surfacing, whereby, over a period of years or decades, a large percentage of buried tires simply work their way to the surface of the landfill. At one time, tires were collected by waste management companies for a small fee. The tires were sorted, the good ones going for retreading and the balance discarded in above-ground storage piles. Tire piles are not only aesthetically disagreeable, but if mismanaged pose a fire hazard. Tire fires are characterized by incomplete combustion resulting in thick clouds of toxic black smoke and the liberation of toxic oils. Since the Hagersville tire fire of 12 February 1990, a number of Canadian provinces have re-examined their approach to used-tire management, and have initiated programs to promote tire recycling and the development of markets for recycled tire products.

RECYCLING: PROCESSES AND PRODUCTS

A. Whole Tires

In Canada, snow tires have been largely replaced by all-weather radials. As the tread wears, these tires have decreased traction on snowy roads, and motorists often replace them before they are completely worn out. These partially worn tires are collected, shipped, and resold in "warm" third-world countries, where they may be capable of tens of thousands of additional kilometres on dry roads. Also, many worn but undamaged tires are returned to the factory for retreading; in Ontario, over a million truck tires are retreaded each year. The market for retreaded car tires is relatively small, however, as new tires at the low end of the price range may be nearly as cheap and, in addition, many consumers perceive retreaded tires as less safe.

A few discarded tires find use as boat fenders and in playground equipment. An application involving slightly more processing consists of setting groups of three or more tires in a concrete base and sinking them in the ocean as artificial reefs. One such project in the eastern United States used 400,000 tires to create a series of reefs from New England to Florida. They provided improved habitat for certain types of game fish and also helped rehabilitate polluted bottom areas. The total cost of this project was less than the commercial disposal costs for the tires would have been.(1) In Canada, connected webs of tires have been used to line the surface of freshly cleared reservoir slopes at hydroelectric projects. These tire webs stabilize the underwater slope and provide habitat for freshwater animals. Whole tires are also used for erosion control and for the stabilization of mine tailings ponds. In the Maritimes, old tires are often used to construct dredges for scallop fishing. All of these uses for old tires, however, account for only a very small percentage of those discarded annually.

B. Cut Tires

In the United States, approximately 1.5% of discarded tires are cut into pieces to make such products as shoe soles, gaskets, shims and blasting mats for using over rock before dynamiting.(2) The extent of this type of scrap-tire use in Canada is unknown.

C. Chipped or Shredded Tires

A single pass through a tire shredder produces tire strips from 15 to 40 centimetres long. If the market demand for tire chips or tire crumb is weak, the used tires will receive no further processing and the shreds will be buried in a landfill. Tire shreds take up eight times less landfill space than whole tires and they do not resurface. Shredding plants are generally constructed close to the supply of tires as shreds are cheaper to transport than bulky whole tires.

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(1) R.B. Stone, C.C. Buchanan and F.W. Steimle, *Scrap Tires as Artificial Reefs*, U.S. Environmental Protection Agency, 1974.

(2) Canadian Council of Ministers of the Environment, Working Group on Used Tires, *Processing Technologies and Manufactured Products From Used Tires*, January 1991, 14 p.

To produce tire chips, it is necessary to pass the shreds through a two-stage shredder, or to re-circulate them within the primary shredder until they are reduced to an appropriate size, usually two to five centimetres. Tire chips may be further processed to crumb, used as feed in waste-to-energy incinerators, or used directly in a number of applications such as road bed material, as the core of earthen embankments and in septic tank drainage fields.[3]

The use of tire chips as road base material appears to be a promising application with the potential of consuming large numbers of used tires. In Minnesota, tire chips were used at a thickness of 0.6 to 2.5 metres as the bottom base material, then overlaid with gravel and the normal two layers of asphalt. The open nature of the chips was found to allow good water drainage through the base, and the extent of frost heaving was reduced. In a controlled test in Maine, a layer of chips 15 to 30 centimetres deep reduced frost penetration from 130 to 90 centimetres, and subsequent frost heaves from 9 to 3.5 centimetres.

Tire chips are also being used in landfill engineering applications. At some new landfill sites, chips are placed on top of the bottom plastic liner in the deepest part of the pit, where they act as a porous filter, separating the leachate from the garbage above. The collected leachate is pumped out and given waste water treatment. Chips may also be used as a daily landfill cover to suppress odours and dust and to discourage vermin. In addition, tire chips have been found to be superior to wood chips as a means of improving aeration in composted sewage sludge.[4]

D. Tire Crumb

Tire crumb may be produced mechanically or by a cryogenic freezing process. In the mechanical process, tires are reduced to chips and then put through granulators which separate and remove loose steel and fibre and further reduce rubber particle size. Finally, the small rubber chunks are ground in a cracker mill to produce rubber crumb of 30 to 40 mesh

(3) *Ibid.*, (1991).

(4) Canadian Council of Ministers of the Environment, *Harmonized Economic Instruments for Used Tires*, 3 August 1994, 146 p.

size.[(5)] In the cryogenic process, tire chips are frozen in liquid nitrogen as they pass through a cryogenic tunnel. They then pass through a series of cracker mills where they are shattered into their three component parts: rubber, steel and fabric. Although the cryogenic process is the more expensive of the two, it produces smoother and smaller crumbs.[(6)]

Rubber crumb is sold as feedstock for chemical devulcanization or reclamation (pyrolysis) processes, added to asphalt for highway paving and pavement sealers, or used for the production of a large number of recycled rubber-containing products (Table 1).

The recycled rubber market is faced with a major hurdle in that recycled rubber products are either equal to or lower in quality than products made from virgin rubber, yet they are generally more expensive to make. As a result, many rubber recycling enterprises have gone out of business when government assistance was phased out.

Rubberized asphalt is more expensive than normal asphalt, but has not proved to be superior to it; in fact, many transportation engineers are sceptical of its merits. When it is time to repave a rubberized-asphalt road, the top layer cannot be stripped off, heated and reused, because the heat burns the rubber and releases toxic emissions.[(7)] In addition, rubberized asphalt is considered by some to be "environmentally unfriendly," as the process for making it consumes 25% more petroleum. Research and development efforts to produce better rubberized asphalt technologies are on-going. One area of apparent success is the development of a "Cold In-Place Asphalt Recycling" process, that is said to be cost-effective.[(8)]

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(5) Mesh size denotes the number of holes per linear inch in a screen through which rubber crumb must pass; 40 mesh is, therefore, finer than 30 mesh.

(6) Canadian Council of Ministers of the Environment (1994).

(7) B. Reguly, "Blowout: Ontario's Tire-recycling Scheme Skids Off Its Course," *Financial Times*, 29 June 1992, p. 15.

(8) J. Emery, "Mix Design, Life Cycle Cost Analysis - Modified Cold In Place Asphalt Recycling," Technology Transfer Workshop on Cost Effective Cold In Place Recycling and Cold Recycling of Asphalt Pavement, Ottawa Palladium, Kanata, Ontario, 2 April 1996.

Table 1 - Applications for Recycled Rubber

Sport Surfaces:

- Kindergarten Playgrounds and Recreation Areas
- School Sports Areas
- Athletic Tracks
- Tennis and Basketball Courts
- Golf Tee-Off Areas
- Swimming Pool Surrounds and Garden Paths
- Lawn Bowling Greens
- Non-Slip Boat Dock Surfaces

Automotive Industry:

- Bumpers
- Car Body Underseal and Rustproofing Materials
- Splash Guards and Fenders
- Floor Mats for Cars and Trucks
- Floor Liners for Trucks and Vans
- Dunnage Materials for Shipping

Construction:

- Hospital, Industrial, and Bathroom Flooring
- Floor Tile
- Carpet Underlay
- Waterproofing Compounds for Roofs and Walls
- Foundation Waterproofing
- Dam, Silo, and Roof Liners

Geotechnical/Asphalt Applications:

- Rubberized Asphalt for Roads and Driveways
- Sub-base for Horse Racing Tracks
- Subsoil Drainage
- Drainage Pipes
- Soil Conditioner
- Filtering Agent for Mercury and Metallic Surfaces
- Porous Irrigation Pipes
- Road Building and Repair

Adhesives and Sealants:

- Adhesives and Sealing Compounds
- Textured and Non-Slip Paints
- Compounding Ingredient (Filler) for Rubber Mouldings and Extrusions
- Compounds for Conveyor Belting Repair
- Expansion Joint Compounds
- Roof Coating and Waterproofing

Shock Absorption and Safety Products:

- Shock Absorbing Pads for Rails and Machinery
- Sound Barriers for Highways
- Crash Barriers
- Abrasion Lining in Mining Equipment

Rubber and Plastic Products:

- Pipe Insulation and Lining
- Baseboards and Kickplates
- Flower Pots

- Garbage Cans
- Shoe Soles and Heels
- Wire and Cable Insulation
- Industrial and Agricultural Tires
- Barn Mats and Flooring
- Conveyor Rollers and Idlers
- Filler in Many Plastic Mouldings and Extrusions

E. Devulcanization

In the process of devulcanization, used rubber is returned to its raw state as a soft, tacky, plastic material, which can then be used in the production of a variety of moulded or die cut rubber materials, such as mats, tubs, and pails. A great deal of research has gone into rubber devulcanization; however, the final renewed material has slightly different chemical properties from virgin rubber. The renewed material is rigid, whereas virgin rubber is composed of long, flexible strands.[9] The devulcanized material does not meet the stringent requirements of modern tire manufacture, nor can it be used in the manufacture of flexible products such as hoses. As these applications account for 85% of Canada's rubber market,[10] the potential supply of devulcanized rubber tends to exceed demand. In addition, the cost of processing old tires, particularly modern radial tires with steel belts, into devulcanized rubber exceeds the cost of virgin rubber production.

F. Reclamation (Pyrolysis)

Pyrolysis is a thermal process that can degrade used tires to their chemical constituents. The traditional process involves burning tires under conditions of oxygen limitation so that the tire material is not completely converted to gases and ash. In 1994, a Canadian company, Exxadon/EWMC, patented a new tire pyrolysis process (the Emery

(9) C. Mahood, "Provinces Stalled on Tire Disposal," *Globe & Mail* (Toronto), 2 January 1993, p. A1.

(10) *Ibid.*

Microwave Process) that breaks tires down to their component parts more efficiently. The typical automobile tire contains approximately 4 litres of oil, about 230 grams of fibre, a kilogram or more of carbon black and about a kilogram each of steel and methane. At several traditional small-scale pyrolysis plants in operation in Japan and the United States, the methane is burned to produce steam heat and electricity and the carbon black and oil are sold to industrial users. Recycled carbon black is acceptable for use in industrial hoses, mats, roofing materials and mouldings.[(11)] The tire industry uses a great deal of carbon black to give strength to their product but unfortunately recycled carbon black contains too many contaminants for use in new tires.

G. Energy Recovery

The production of energy from waste, although not a form of recycling in the strict sense of the word, is an economically sound end-use for used tires that are not good enough for resale in third-world countries. Public perception of incineration, however, makes it difficult to promote as a waste management option. When tires burn in the open, as in the Hagersville tire fire, the temperature of combustion is not high enough for complete incineration and toxic compounds are released to the air and soil. On the other hand, complete combustion to inorganic gases and ash can be achieved through high-temperature incineration, as is practised in cement kilns and coal-fired thermal-electric generating stations. Very little is mentioned of research efforts showing that tires can be safely incinerated at high temperatures and the released energy used for industrial applications; consequently, concerned citizens and environmental groups tend to oppose all tire incineration on the grounds that it might pose a health hazard.

On a weight basis, the energy content of scrap rubber is 15 to 20% greater than that of coal.[(12)] [(13)] The sulphur content of vulcanized rubber is approximately the same as that

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(11) J.P. Hicks, "A Whole New Dimension to Retreads," *New York Times*, 17 November 1991, p. 9.

(12) M. Turgeon, *Risques environnementaux associés au dépôt de pneus de Saint-Amable*, Ministère de l'Environnement du Québec, Direction de la récupération et du recyclage, Quebec, 20 October 1988, p. 5.

(13) Manitoba Environment, Waste Reduction and Prevention Branch, *Report of the Waste Reduction and Prevention Committee on Used Tires*, April 1991, p. 5-7.

of the Appalachian coal burnt by many Ontario industries, and lower than that of Cape Breton coal. Concern about sulphur dioxide and nitrous oxide emissions from coal-fired industries, plus the more recent concern of global warming due to carbon dioxide emissions, have stimulated advances in the development of clean-coal technologies.[14] Advances in new combustion technologies, plus post-combustion cleaning technologies (scrubbers) have greatly improved combustion efficiency and reduced emissions. The higher energy content of rubber means that the incineration of used tires in "state-of-the-art" coal furnaces would release fewer contaminants per unit energy, and decrease the use of non-renewable fossil fuels.[15] A scientific study commissioned by St. Marys Cement Company, Ontario, compared the emissions from cement kilns fed conventional fossil fuels to the emissions from five Canadian and two American cement plants where scrap tires were used as supplementary fuel in proportions ranging from 5-20%. No significant difference in emissions could be detected, and emission levels for all plants using scrap tires were well within the limits set in both the Ontario air emission standards and guidelines, and the Canadian Council of Ministers of the Environment (CCME) guidelines for the use of hazardous and non-hazardous wastes in cement kilns.[16]

In most countries, cement kilns are allowed to use scrap tires as fuel. Canadian cement kilns in Quebec, Alberta and British Columbia may off-set a portion of their fossil fuel needs with used tires. In Manitoba, used tires are burnt to melt aluminium in a small recycling plant and in Charlottetown, P.E.I., shredded tires are burnt along with municipal garbage to generate electricity at the local incinerator. In Modesto, California, a waste-to-energy plant converts 400,000 tires monthly into 14.5 megawatts of electricity. This plant began operation in 1987 at a capital cost of $42 million (U.S.).[17]

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(14) United States Department of Energy, Clean Coal Technology, *The New Coal Era*, DOE/FE0217P, Washington, D.C., 1991, p. 8-29.

(15) Manitoba Environment (1991).

(16) "TDF Found to Have Little Impact on Cement Kiln Emissions," *Eco-Log Week, A Report on Waste Management & Industrial Pollution Control*, Vol. 23, 28 July 1995, p. 1.

(17) Manitoba Environment (1991).

THE TIRE RECYCLING INDUSTRY IN CANADA

Tire recycling in Canada is a diverse industry ranging from low-technology "cottage" plants to companies with international patents on new recycling processes which market their technology and products world-wide. At the low-technology end of the industry are small companies that knit whole used tires into such things as blasting mats and playground equipment. One interesting small enterprise is Gofor Supplies Ltd. of Courtenay, B.C., which, by threading lines of used tires side-by-side on central shafts, produces rubber boomsticks for use as bumpers between a tug boat and a log boom.

Recovery Technology Inc. of Mississauga, Extruda-Rail of Calgary, and Exxadon/EWMC are Canada's high-technology tire-recycling companies. Recovery Technology has developed a new process for the conversion of steel-belted tires to rubber crumb. This technology, which recovers 98% of the useable rubber from the steel, carbon, and fabric components, has been licensed world-wide. This company also produces matting materials for the industrial workplace and for animal stalls and enclosures. Extruda-Rail holds international patents on a process it developed to convert rubber crumb into lengths of extruded renewed rubber for use in such applications as railway crossing panels and the flange fillers that hold the rails. The company supplies the entire Canadian market but exports the majority of its production to the United States, Asia and Europe. As previously mentioned, Exxadon/EWMC has developed a microwave pyrolysis process leading to the marketing of the oil, carbon black and steel components of tires and has licensed its technology to other companies in North America, Europe, the Middle East and Russia.[18] These large companies are doing relatively well in the tire-recycling business, as are some small companies that fill a specific market niche.

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(18) "Permanent C of A Granted to Exxadon Tire Recycling Plant," *Eco.Log Week, A Report on Waste Management & Industrial Pollution Control*, 6 September 1996, p. 2.

GOVERNMENT ACTION

As used tires are categorized as municipal solid waste, their disposal falls under provincial and municipal jurisdiction. The federal government considers used tires to be a non-hazardous waste that poses an environmental and human health problem only when improperly managed and there are no federal programs specifically promoting tire recycling. As of 1 April 1996, however, innovative tire recycling research and development projects qualified for support under the *Technology Partnerships Canada* program sponsored by Industry Canada. Another area of federal involvement is Environment Canada's *Hazardous Spills Prevention and Response Program,* whose funds go to support regional response crews, spill prevention, training, spills research, the development of cleanup instruments and techniques, the purchase of improved equipment, and the development of a joint Canada-U.S. strategy for spills on land and in boundary rivers and lakes.[19] Accordingly, this program plays an important role in tire-fire prevention and has been called upon to assist in clean-up operations.

In Canada's less populated regions, used tires have not posed a problem. In the Northwest Territories, Yukon, Saskatchewan, Nova Scotia and Newfoundland there are no restrictions on landfilling used tires. In the rest of Canada, used tires are diverted from landfills and recycling programs have been established. Each provincial program operates in isolation of the others, and they vary in complexity. In New Brunswick, for example, used tires are diverted from the solid waste stream, collected, chipped, and then used as road bed material or sold as fuel to a pulp mill in Maine. British Columbia, Alberta, Manitoba, Quebec and Prince Edward Island finance recycling initiatives through a special levy on the purchase of new tires. For example, the British Columbia government uses its tire tax to fund a recycling research demonstration and development program; it pays 60 cents per tire to offset transportation costs, 90 cents per tire to companies that use tires as fuel, and up to a $1.50 per tire, depending on how much of the tire is reused, to recycling companies. The Quebec program is similar, but much more complex, due to a mandatory paper trail of sales invoices and tire collection receipts required to ensure that public funds will not be expended on out-of-province tires. Recyclers must be able to prove that the tires originated in Quebec and that the

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(19) Environment Canada, *Hazardous Spills Prevention and Response Program Announced*, News Release PR-HQ-091-35, 5 November 1991.

final product (for example, rubber crumb) has been sold, before the government will pass along the subsidy. The reporting requirements are so extensive that the Quebec government has developed a computer software package to assist Quebec tire recyclers. In Ontario, the extensive grants program initiated to establish a tire-recycling infrastructure has been greatly reduced now that this infrastructure is in place and tire recycling is essentially a market-driven industry. Consumers pay tire retailers a disposal fee which covers transportation and the cost of landfilling tire chips, should that be necessary. The majority of Ontario tires (60%) are now reused or recycled in some fashion, and nearly all of the balance are chipped and exported to the United States.

In the aftermath of the Hagersville tire fire, the issue of used-tire management was taken up by the CCME, initially under its *National Waste Management Strategy*. The provinces were encouraged to adopt plans and make the diversion of used tires from the waste stream an integral part of the CCME'S proposed goal of a 50% reduction in waste by the year 2000. The CCME also struck a working group on used tires to study used-tire management and prepare an inventory of scrap tires.[20] After the publication of this study in October 1990, the working group released two follow-up studies: *Proposed Guideline for the Outdoor Storage of Used Tires*, December 1990, and *Processing Technologies and Manufactured Products from Used Tires*, January 1991.

Each province that has developed a tire recycling program has done so in isolation of the others. This, in turn, raised concerns that there migh. be an interprovincial flow of used tires to the provinces with the most generous recycling subsidies. In response, the CCME funded and, on 3 August 1994, published the document: *Harmonized Economic Instruments for Used Tires*. One of its principal findings was that, although the provincial programs were not harmonized, there was little evidence that program differences were creating significant market inefficiencies. This study described a number of potential models for harmonized economic instruments for used tires. These models could be adopted by those provinces so far without a used tire program, or by the other provinces as they attempt to make their programs more self supporting.

(20) Canadian Council of Ministers of the Environment, Working Group on Used Tires, *Inventory and Management of Used Tires / Inventaire et gestion des vieux pneus*, compilation of multiple documents, October 1990,.